Amendments to the Specification:

Please amend the specification as follows:

Please replace the paragraph on page 1, lines 15-17 with the following paragraph:

1. Field of the Invention

The invention relates to the field of semiconductor processing of films and in particular to processing nonsilicon films ~~on heterostructures~~.

Please replace the paragraph on page 2, line 2 to page 3, line 4 with the following paragraph:

The invention is an improvement in a method of epitaxially growing heterostructures on a virtual substrate comprised of an optoelectronic device substrate and handle substrate. The method comprises the step of initiating bonding of the device substrate to the handle substrate. The device substrate is composed of a material suitable for fabrication of optoelectronic devices therein and the handle substrate is composed of an inexpensive material suitable for providing mechanical support. The mechanical strength of the <u>bond between</u> device and handle substrates is improved. The device substrate is thinned to leave a single-crystal film on the virtual substrate such as by exfoliation of a device film from the device substrate. An upper portion of the device film exfoliated from the device substrate is removed to provide a smoother and less defect prone surface is provided for subsequent optoelectronic device fabrication. The heterostructure is epitaxially grown on the smoothed surface.

Please replace the paragraph on page 2, line 2 to page 3, line 4 with the following paragraph:

The invention is also defined as an improvement in a heterostructure device layer which is epitaxially grown on a virtual substrate. The improvement comprises a device substrate and a handle substrate from which the virtual substrate is formed. The device substrate is bonded to the handle substrate and is composed of a material suitable for fabrication of optoelectronic devices. The handle substrate is composed of a material suitable for providing mechanical support. The mechanical strength of the bond between device and handle substrates is improved and the device substrate is thinned to leave a single-crystal film on the virtual substrate such as by exfoliation of a device film from the device substrate. An upper portion of the device film exfoliated from the device substrate is removed to provide a smoother and less defect prone surface for an optoelectronic device. A heterostructure is epitaxially grown on the smoothed surface in which an optoelectronic device may be fabricated.

Please replace the paragraph on page 4 lines 19-20 with the following paragraph:

Fig. 1 is a block diagram ~~illustrated~~ illustrating two alternative fabrication strategies for a virtual substrate.

Please replace the paragraph on page 5, lines 16-17 with the following paragraph:

Fig. 9 is a graph of the strain state as a function of temperature for [an] a GaAs/Si wafer bonded virtual substrate.

Please replace the paragraph on page 8, lines 14-20 with the following paragraph:

The materials of interest for device substrate 10 for the discussion below can be considered all materials that are relevant to wafer bonded virtual substrate device film materials

for opto-electronic, high-gain device fabrication as ~~diagrammatically~~ illustrated diagrammatically in Fig. 2: these include, but are not limited to III/V compound semiconductors (i.e. GaAs, InP, GaN, etc.), II/VI semiconductors (i.e. CdTe, etc.), group IV semiconductors (i.e. Ge for GaAs family growth), and optically important Ferroelectric oxides (i.e. $LiNbO_4$, $BaTiO_4$, etc.).

Please replace the paragraph on page 9, lines 3-19 with the following paragraph:

A generic process for fabricating such virtual substrates 16 comprises the following steps:

1) The device substrate 10 and handle substrate 14 may need pre-bonding treatment to allow for the removal of a thin film 12 (~~i.e.~~ e.g.. ion-implantation into device substrate 10 as diagrammatically depicted by number 11 in Fig. 3a).

2) The device substrate 10 is cleaned and/or passivated to facilitate bonding.

3) Bonding is initiated as diagrammatically shown in Fig. 4a.

4) The bond 42 is strengthened ~~to improve the mechanical strength of the device substrate 10 and handle substrate 14~~.

5) The device substrate 10 is thinned to leave a single-crystal film 12 on the finished virtual substrate 16 as shown in Fig. 4b for an ion-implanted substrate.

6) In the case of ion implantation induced layer exfoliation, the device substrate 10 from which the device film 12 was derived can be reprocessed by a means of surface polishing to allow the reuse of the substrate 10 to transfer another device film as illustrated in Fig.[4b] 5a and Fig. 5b.

Please replace the paragraph on page 11, line 21 to page 12, line 7 with the following paragraph:

Following implantation and prior to bonding, it is necessary to passivate the surface of both the device and handle substrates 10, 14 to allow hydrophobic wafer bonding. The specific chemical process necessary is device substrate specific. The purpose of this step is to enable the formation of an intimate covalent bond between the device film 12 and handle substrate 14 in the finished virtual substrate 16 allowing for the possibility of ohmic, low-resistance interface electrical properties. A necessary step in enabling this finished device structure will be the elimination of adsorbed water on the surface by means of a low temperature bake in an inert atmosphere or in vacuum. The bake should reach a temperature such that the vapor pressure of water at that temperature is well ~~below~~ <u>above</u> the partial pressure of water in the surrounding ambient.

Please replace the paragraph on page 13, lines 7-18 with the following paragraph:

Another enabling technology for extending this process to a wide range of optoelectronic materials is the use of a deposited surface modification layer ~~18~~ <u>40</u> of arbitrary thickness to change the nature of the physical interaction between the substrates 10, 14 as depicted in Figs. 6a and 6b. This can be done in one of three ways, where X stands for any type of composition compatible with the disclosed method:

a. Deposition of a layer ~~18~~ <u>40</u> of material X on the device substrate 10 to enable an X-handle material bond.

b. Deposition of a layer ~~18~~ <u>40</u> of material X on the handle substrate 14 to enable an X-device material bond.

c. Deposition of a layer ~~18~~ 40 of material X on both substrates to enable an X-X bond.

Please replace the paragraph on page 13, line 19 to page 14, line 4 with the following paragraph:

This technology enables the integration of a wide range of optoelectronic materials by mastering bonding with a material which is compatible or amenable ~~amendable~~ to the disclosed process, which for the moment is referenced simply as material X. The generic process is illustrated in Figs. 6a and 6b. Fig. 6a illustrates the surface modification of the implanted device substrate with either a crystalline or amorphous film 40 of the same chemical identity as the handle substrate 14. Fig. 6b illustrates a wafer bonded substrate stack using this technique showing the device substrate 10, the ion implanted damage region 13, the device thin film 12, the deposited bond mediating film 40, the bonded interface 42, and the handle substrate 14.

Please replace the paragraph on page 15, lines 2-16 with the following paragraph:

Following surface passivation, it may be necessary to remove residual particle contamination on the bonding surfaces of the device and handle substrates 10 and 14. This has been efficiently done by performing a clean with a CO_2 particle jet [20] as depicted in Figs. 4a and 4b. Fig. 4a is a diagram of a device substrate 10 and handle substrate 14 stack following ion implantation and initial bonding, showing the undamaged bulk device substrate 10, the ion implanted damage layer 13, the device thin film 12, the wafer bonded device/handle interface 42, and the handle substrate 14. Fig. 4b is a diagram showing the wafer bonded virtual substrate 16 following the anneal and layer exfoliation, and showing the undamaged bulk device substrate 10 with its ion implanted damaged surface region 13. Also shown is the wafer bonded virtual

substrate 16 comprised of the ion implantation damaged surface region 13 of the device film 12, the undamaged transferred device film 12, the wafer bonded interface 42, and the handle substrate 14. The substrates 10 and/or 14 [is] are held at an elevated temperature and a throttled gas/particle jet of CO_2 is impinged on the surface of substrates 10, 14 removing particles by a combined physical impact and thermophoretic lifting effect.

Please replace the paragraph on page 21, lines 17-21 with the following paragraph:

Following the transfer of the device ~~layer 10~~ film in the ion implantation induced layer transfer process, the near surface region of the device film 12 is both rough and defect rich. This layer must be controllably removed to leave a surface that is useful for subsequent processing to fabricate an optoelectronic device as shown in Figs. 11a and 11b. Depending on the device layer 10 this can be accomplished by:

Please replace the paragraph on page 25, lines 8-15 with the following paragraph:

The finished virtual substrate 16 is meant to serve as a template for growth of an optoelectronic device through hetero-epitaxy. Through careful device layer modification, epitaxy of a wide range of optoelectronic devices is made possible. A representative image of such a structure is shown in Figs. 13a and 13b. Fig. 13a is a diagram which shows the completed wafer bonded virtual substrate 16 comprised of a thin device film 12, a wafer bonded interface 42 and a handle substrate 14. Fig. 13b is a diagram which shows a wafer bonded virtual substrate 16 with an epitaxially grown device [40] 50 fabricated on the device thin film 12.

Please replace the paragraph on page 25, line 18 to page 26, line 4 with the following paragraph:

One potential challenge in implementing wafer bonded virtual substrates in the fabrication of devices in or on the transferred layer by standard processing such as MOCVD, diffusion, implantation, and lithography is the possibility of wafer bow due to the presence of thermal expansion derived strain in the transferred layer. A practical approach to minimizing this effect would be to deposit a strain compensation layer on the back surface of the handle substrate 14 as shown in Fig. 14. Fig. 14 is a diagram which schematically shows an optoelectronic structure [40] 50 grown on a wafer bonded virtual substrate 16 comprised of the device film 12, the bonded interface 42, the handle substrate 14, and a strain compensation layer 18 deposited on the back surface of the substrate.